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Regional differences in agricultural profitability, government payments, and farmland values

Implications of DuPont expansion

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Abstract

Purpose – The purpose of this paper is to use the DuPont expansion to examine those factors underlying differences in (rates of) return on different crop portfolios over space (ten regions) and time (1960-2004). The paper also estimates the impact of government payments on farmland values through its impact on farm profitability.

Design/methodology/approach – Businesses use the DuPont model to analyze the profitability of a business. This model includes three components: net profit margin, asset turnover, and financial leverage (or assets to equity). It is based on the relationships among these three components and is expressed as a product of ratios. For the purposes of the current study, accrued capital gains from (total) returns are excluded to focus on cash returns "cash flow". Returns from current income are a "cash flow" available in the short run to pay financial obligations. Furthermore, returns from capital gains are not liquid; they are gains in wealth fully captured as capital gains/losses only in the longer term. Following the DuPont approach, the effect of government payments on farm asset values is equal to the sum of the effect of government payments on profit margins plus the effect of government payments on the asset turnover ratio.

Findings – The analysis focuses on agricultural profitability in the ten Economic Research Service (ERS) regions. By comparing the components of the DuPont expansion, profitability differences over time are analyzed. The results indicate that one cause of low profitability in the Corn Belt and Mountain regions is a perpetually low profit margin while the evidence for other regions supports lower asset efficiency. Results show that government payments impact the profit margin and affect value of farm assets in particular farmland values but not asset turnover ratio.

Originality/value – The use of DuPont expansion factor in agriculture is original and really helps us to understand the factors driving profitability in agriculture. Another innovation (originality) in this paper is the theoretical model that connects the DuPont expansion factor, government payments and its impact on farmland values.

Keywords United States of America, Farms, Agriculture, Land, Profit, Assets management

Paper type Research paper

The authors are indebted to the Editor for helpful comments and suggestions. The views expressed in this manuscript represent those of the authors and do not necessarily represent those of the USDA. This project was supported by the USDA Cooperative State Research Education & Extension Service, Hatch project # 0212495 and Louisiana State University Experiment Station project # LAB 93872.

Agricultural Finance Review
Vol. 69 No. 1, 2009
pp. 49-66

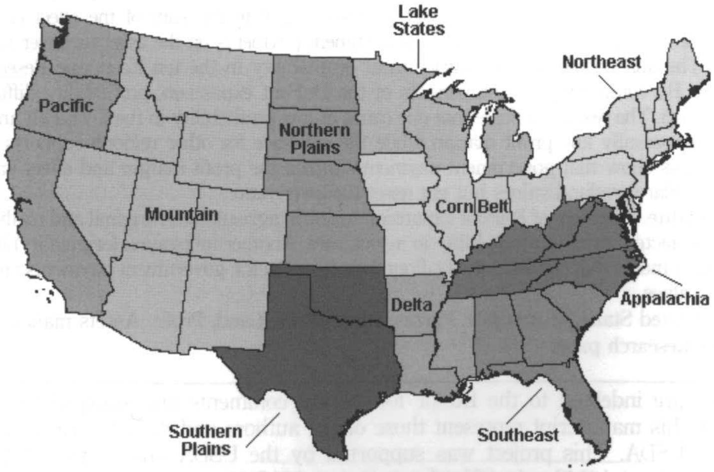
0002-1466
DOI 10.1108/00021460910960462

Introduction

This study uses the DuPont expansion of returns to all factors of production to examine how the financial structure attributes of the agricultural production sector contributed to financial difficulties in the US farm sector from 1960 to 2004. Our analysis focuses on agricultural profitability in the ten Economic Research Service (ERS) regions (see Figure 1). By comparing the components of the DuPont expansion, profitability differences over time are analyzed. Our results indicate that one cause of low profitability in the Corn Belt and Mountain regions is a perpetually low profit margin while the evidence for other regions supports lower asset efficiency. Results show that government payments impact the profit margin but not asset turnover ratio. Thus, government payments affect value of farm assets and in particularly, farmland values predominantly through their impact on profitability.

Two typical characteristics of the US agricultural sector are that the sector suffers from chronic low returns[1] to factors of production (Cochrane, 1979; Tweeten, 1969) and has traditionally experienced boom/bust cycles (Schmitz, 1995; Melichar, 1979). Both of these characteristics can be observed in agricultural returns over the past twenty years. Starting in the mid-1980s, production agriculture in the United States experienced a period of significant financial stress. Following this period of financial difficulty, the sector slowly rebounded to a brief boom period in 1996-1997 only to return to a period of moderate stress in the closing years of that decade. Assessing financial stress within American agriculture involves identifying which farms are more or less profitable. This suggests a macro-level forecast of American agriculture's future structure and financial performance of farms, state and the agricultural sector. Furthermore, any financial analysis should account for time and location.

The future of agricultural production in the US will depend on its profitability within a location, such as a geographical region or an individual state. Blank *et al.* (2005) point out that to remain viable, investments in agriculture must offer returns that are both competitive with those from alternative investments and are sufficient to cover farmers' financial obligations. Indeed, rates of return will affect resource allocation in the long run. For example, O'Rourke and Williamson (1994) conclude that



Source: Economic Research Service, USDA, Washington, DC

Figure 1.
Farm production regions of the US

rates of return converge over the long run as resources flow into more-profitable industries and out of less-profitable industries. Furthermore, Schott (2003) states that differences in agricultural returns across states and regions over time are most likely due to different "crop portfolios". This paper uses the DuPont expansion to examine those factors underlying these differences in (rates of) return on different crop portfolios over space (ten regions, Figure 1) and time (1960-2004). The study also estimates the impact of government payments on farmland values through its impact on farm profitability.

Businesses use the DuPont model[2] to analyze the profitability of a business. This model includes three components: net profit margin, asset turnover, and financial leverage (or assets to equity). It is based on the relationships among these three components and is expressed as a product of ratios[3]. Any decision that influences product prices, per unit costs, volume, and/or output per unit of input (efficiency) will have an impact on net profit margin and/or asset turnover. Further, any decision that affects the amount of borrowed capital will have an impact on the assets to equity ratio.

The next section presents the conceptual model used to examine spatial and temporal factors explaining differences in returns on crop portfolios over space and time. The following section describes the data used and the empirical estimation methodology. The results of our estimation are presented in the next section. Finally, we conclude with a section that discusses the policy implications of DuPont analysis and suggest areas for further study.

Empirical application of the DuPont expansion

The traditional DuPont approach involves the development of a systematic relationship among financial ratios to diagnose the performance of a firm (Reilly and Brown, 2000). The general concept is to decompose financial performance into capital structure, asset efficiency, and production/operational efficiency. The ratios at the firm level are compared against industry standards to inform firm decision makers on the areas where firm performance needs improvement. For example, a low asset turnover ratio, relative to industry standards, might be corrected by increasing advertising expenditures. Application of the DuPont expansion[4] to agriculture has traditionally focused on the capital structure dimension of the decomposition. Collins (1985) developed an optimal debt formulation based on the DuPont expansion. Collins' model showed that policies reducing business risk may induce farmers to increase financial risk. Collins concludes that in addition to the risk-balancing aspect of risk-reducing policy, there may be a risk-balancing effect related to increase in expected farm income. Collins's formulation has been used to study the effects of commodity programs (Featherstone *et al.*, 1988) and changes in tax policy (Moss *et al.*, 1989) on debt. In the current study, we use the DuPont expansion that is employed in optimal debt studies.

We begin by decomposing the rate of return on equity into the rate of return on assets and the asset-to-equity ratios

$$\frac{R}{E} = \left[\frac{R}{A}\right] * \left[\frac{A}{E}\right] \tag{1}$$

where R is the profit defined as gross receipts minus the cost of production, E is the dollar value of equity, and A is the total dollar value of assets. For the purposes of the current study, we exclude accrued capital gains from (total) returns to focus on cash returns "cash flow". Returns from current income are a "cash flow" available in the short run to pay financial obligations. Furthermore, returns from capital gains are not liquid; they are gains in wealth fully captured as capital gains/losses only in the longer term[5].

To focus on asset efficiency, we replace the return on assets (R/A) with the gross margin (defined as sales less cost of production) divided by sales times the asset turnover ratio (defined as sales divided by the level of assets). Expressed mathematically as:

$$\frac{R}{E} = \left[\frac{S-C}{S}\right] * \left[\frac{S}{A}\right] * \left[\frac{A}{E}\right] \tag{2}$$

where S is the level of sales and C is the cost of production. This formulation then decomposes the rate of return on equity into the relative profitability of each unit of sales through the gross margin ratio, the efficiency of asset use through the asset turnover ratio, and a leverage effect through the inverse of the solvency ratio.

Application of the DuPont expansion as defined in Equation (2) is dependent on the multiplicative nature of the expression as an identity. Given that the expression is an identity, it holds at every point with strict equality. Thus, it makes little sense to regress the expansion either using nonlinear least squares or a logarithmic transformation. Similarly, the multiplicative nature of the relationship limits the appeal of the use of simple arithmetic means and standard deviations. Instead, we analyze the implications of the DuPont expansion by assuming that each ratio is log normally distributed. The appeal of this approach becomes apparent by taking the natural log of each side of Equation (2):

$$\ln\left(\frac{R}{E}\right) = \ln\left(\frac{S-C}{S}\right) + \ln\left(\frac{S}{A}\right) + \ln\left(\frac{A}{E}\right) \tag{3}$$

where ln(.) is the natural log operator. The logarithmic transformation yields a linear multiplicative system of variables amenable to analysis using the multivariate normal distribution. Since Equation (3) is also a strict identity, we can decompose the rate of return on equity into each component.

Based on this formulation, we then analyze the regional differences in profitability by computing the average for each ratio within each ERS region using the logarithmic normal distribution. Next we compute the same average across the entire sample. The statistical difference between the regional distributions can then be computed using a likelihood ratio test using the log normal distribution. To assess the impact of government payments on farm assets[6] one needs to establish the relationship between government payments and farm profitability. The probability density function for the log normal distribution can be written as:

$$f(x;\mu,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left\{-\frac{(\ln(x)-\mu)^2}{2\sigma^2}\right\}\frac{1}{x} \tag{4}$$

where x is the log normally distributed random variable, and μ and σ are parameters of the distribution. Following Mood *et al.*, these population parameters can be estimated by:

$$\hat{\mu} = \frac{1}{N}\sum_{i=1}^{N}\ln(x_i)$$
$$\hat{\sigma}^2 = \frac{1}{N}\sum_{i=1}^{N}(\ln(x_i) - \hat{\mu})^2 \tag{5}$$

where N is the number of observations in the sample. The mean of the log normally distributed random variables then becomes:

$$E[x] = \exp\left[\frac{\hat{\sigma}^2}{2} + \hat{\mu}\right] \tag{6}$$

and the variance:

$$V[x] = p\left[2\hat{\sigma}^2 + 2\hat{\mu}\right] - \exp\left(\hat{\sigma}^2 + 2\hat{\mu}\right). \tag{7}$$

The likelihood ratio for differences in regional means then defines the likelihood function as the product of the distribution function defined in Equation (4) based on a single μ and σ defined for the entire sample (the restricted likelihood function, L_R), and the same likelihood function where different μ and σ are defined for each region (the unrestricted likelihood function, L_U). The statistical significance of regional effects can then be calculated as:

$$\tau = 2[\ln(L_U) - \ln(L_R)] \sim \chi_r^2 \tag{8}$$

where r is the number of restrictions, in this case 18 (Mood *et al.*, 1974).

Based on the above formulation one can study the impact of government payments on farm profitability and its impact on farm business asset values. Specifically, the rate of return on assets (ROA) is a ratio of returns to agricultural assets to the value of total farm assets (V) and, hence, the change in the rate of return on assets is a function of the change in value of farm assets:

$$\begin{aligned}\mathrm{ROA} = \frac{R}{V} \Rightarrow \mathrm{d\,ROA} &= \frac{\mathrm{d}R}{V} - \frac{R}{V^2}\mathrm{d}V \\ &= \frac{\mathrm{d}R}{V} - \frac{\mathrm{ROA}}{V}\mathrm{d}V.\end{aligned} \tag{9}$$

Next, we note the changes in the rate of return on assets are also a function of changes in the level of government payments (G), or:

$$\frac{\mathrm{dROA}}{\mathrm{d}G} = \frac{1}{V}\frac{\mathrm{d}R}{\mathrm{d}G} - \frac{\mathrm{ROA}}{V}\frac{\mathrm{d}V}{\mathrm{d}G}. \tag{10}$$

By definition $R = R_M + G$ where R_M are market-based returns; therefore, $\mathrm{d}R/\mathrm{d}G = 1$.

Making this substitution and rearranging the forgoing equation yields:

$$\begin{aligned}\frac{dV}{dG}\frac{\text{ROA}}{V} &= \frac{d\text{ROA}}{dG} - \frac{1}{V} \\ \frac{dV}{dG} &= \frac{d\text{ROA}}{dG}\frac{V}{\text{ROA}} - \frac{1}{\text{ROA}}\end{aligned} \tag{11}$$

Multiplying through each side by G/V yields the logarithmic differential form:

$$\begin{aligned}\frac{dV}{dG}\frac{G}{V} &= \frac{d\text{ROA}}{dG}\frac{G}{V}\frac{V}{\text{ROA}} - \frac{G}{V\text{ROA}} \\ \Rightarrow \frac{d\ \ln(V)}{d\ \ln(G)} &= \frac{d\ \ln(\text{ROA})}{d\ \ln(G)} - \frac{G}{G + R_M}.\end{aligned} \tag{12}$$

Linking this formulation to the DuPont expansion in Equation (3):

$$\ln(\text{ROA}) = \ln\left(\frac{S - C}{S}\right) + \ln\left(\frac{S}{A}\right). \tag{13}$$

Differentiating the logarithmic terms with respect to the natural logarithm of government payments yields:

$$\begin{aligned}\frac{d\ \ln(\text{ROA})}{d\ \ln(G)} &= \frac{d\ \ln(S - C/S)}{d\ \ln(G)} + \frac{d\ \ln(S/A)}{d\ \ln(G)} \\ \Rightarrow \frac{d\ \ln(V)}{d\ \ln(G)} &= \left[\frac{d\ \ln(S - C/S)}{d\ \ln(G)} + \frac{d\ \ln(S/A)}{d\ \ln(G)}\right] - \frac{G}{G + R_M}.\end{aligned} \tag{14}$$

Thus, following the DuPont approach, the effect of government payments on farm asset values is equal to the sum of the effect of government payments on profit margins plus the effect of government payments on the asset turnover ratio. To determine these effects we estimate two panel models:

$$\begin{aligned}d\ \ln(S - C/S) &= \alpha_0 + \alpha_1 d\ln(G) + \varepsilon_1 \\ d\ln(S/A) &= \beta_0 + \beta_1 d\ln(G) + \varepsilon_2.\end{aligned} \tag{15}$$

Thus, the effect of government payments on farm asset values through the DuPont expansion becomes:

$$\frac{d\ \ln(V)}{d\ \ln(G)} = \left[\hat{\alpha}_1 + \hat{\beta}_1\right] - \frac{\bar{G}}{\bar{G} + \bar{R}_M} \tag{16}$$

where $\hat{\alpha}_1$ and $\hat{\beta}_1$ are estimated parameters from Equation (15), and $\bar{G}$ and $\bar{R}_M$ are average levels for government payments and market returns (in fact the last term is simply the average share of government payments in farm income).

Data and empirical results

We use state level data from the USDA's sector accounts. We define income as cash sales net of direct cash expenses, capital consumption, and interest. As such, it represents returns to operators' labor, management, and farm assets. All dollar figures (returns, expenses, sales or income, agricultural assets, and equity) were converted to real dollars using the implicit gross domestic product (GDP) deflator and averaged over 1960-1969, 1970-1979, 1980-1989, 1990-1999, and 2000-2004. The resulting data contained positive net returns for every state except West Virginia in the 1980s. The average ratios in the DuPont expansion are presented in Tables I-IV. We will first present the results of the DuPont expansion analysis, which includes government payments (they are included in the cash receipts).

Results for the DuPont expansion

In general, these results indicate that the rates of return to all factors were consistently higher than the national average in the Southeast, Delta, Northern Plains, and Pacific regions, and significantly lower than the national average in the Corn Belt, Southern Plains, and Mountain States regions. In addition, the regional variation in the rate of return to all factors is relatively large for the Northeast, Appalachia and the Mountain States. However, this result would be expected because these regions contain more states (Tables I-IV).

The relative differences between the national average rate of return to all factors and the regional figures can be decomposed following the DuPont results. The higher rate of return to all factors in the Southeast (48 percent above the national average) can be attributed both to a higher asset turnover ratio and a higher than average profit margin. In the Southeast, on average, 39 percent of the increased rate of return to all factors is attributable to increased asset turnover and 63 percent to higher gross margins (Tables I-IV). However, the opposite is true for the Pacific region. For example, in the Pacific region 32 percent of the increased rate of return to all factors is attributable to increased asset turnover and 26 percent to higher gross margins. Similarly, 35 percent of the increased rate of return to all factors in the Delta region is attributable to higher gross margins.

Lower return to factors of production in the Corn Belt region results from two opposing forces. First, the asset turnover ratio is 20 percent lower than the national average over time. However, the profit margin averages 5 percent over the national average. Similarly, Appalachia has a lower asset turnover ratio and higher gross margins than the national average. These results are in contrast to the Mountain States that have experienced both lower asset turnover and gross margins over time.

Profit margin results also support the relatively local nature of the financial crisis of the 1980s. Specifically, profit margins fell by over 40 percent in the Lake States, Corn Belt, and Northern Plains, during the 1980s compared with little change in gross margins between the 1960s and 1970s. During the same period, (1980s), profit margins increased slightly in the Southeast and Pacific regions. Thus the farm financial crisis of the 1980s was localized with respect to production region. There were general improvements in gross margins in the 1990s with the exception of the Lake States. In recent years (2000s), profit margins have increased significantly in the Southeast, Delta, and Southern Plains regions, as compared to the national average, due to both an increase in government payments to cotton and rice farmers and higher livestock prices. On the other hand, profit margins decreased in the Northeast, Lake States, and

Table I.
DuPont expansion ratio: rate of return to all factors

Region	Average/std. dev. of ratio 1960s	1970s	1980s	1990s	2000s	Percent change from national average 1960s	1970s	1980s	1990s	2000s	Coeff. of var. for rate of return to all factors 1960s	1970s	1980s	1990s	2000s
Northeast	0.0878	0.0566	0.0591	0.0543	0.0428										
	(0.0276)	(0.0280)	(0.0343)	(0.0224)	(0.0323)	17.8	−5.0	13.8	−14.5	−12.7	31.4	49.5	58.0	41.2	75.5
Lake States	0.0870	0.0698	0.0534	0.0457	0.0298										
	(0.0232)	(0.0167)	(0.0125)	(0.0157)	(0.0220)	16.7	17.3	2.8	−28.2	−39.2	26.7	23.9	23.5	34.4	73.8
Corn Belt	0.0714	0.0560	0.0431	0.0520	0.0370										
	(0.0117)	(0.0091)	(0.0126)	(0.0155)	(0.0113)	−4.2	−5.9	−16.9	−18.3	−24.6	16.4	16.3	29.1	29.8	30.5
Northern Plains	0.0792	0.0729	0.0521	0.0825	0.0591										
	(0.0232)	(0.0167)	(0.0125)	(0.0157)	(0.0092)	6.2	22.4	0.4	29.8	20.5	29.3	22.9	24.0	19.0	15.6
Appalachia	0.0783	0.0615	0.0514	0.0906	0.0663										
	(0.0412)	(0.0968)	(0.0437)	(0.1812)	(0.0952)	5.1	3.3	−1.0	42.5	35.2	52.6	157.3	85.0	200.0	143.6
Southeast	0.0912	0.0702	0.0658	0.1009	0.0827										
	(0.0069)	(0.0129)	(0.0312)	(0.0334)	(0.0149)	22.4	17.8	26.7	58.7	68.6	7.6	18.4	47.3	33.1	18.0
Delta States	0.0830	0.0774	0.0522	0.0965	0.0716										
	(0.0148)	(0.0135)	(0.0170)	(0.0169)	(0.0124)	11.3	30.0	0.5	51.8	46.0	17.9	17.4	32.6	17.5	17.3
Southern Plains	0.0507	0.0389	0.0285	0.0492	0.0537										
	(0.0045)	(0.0003)	(0.0025)	(0.0073)	(0.0015)	−32.0	−34.7	−45.2	−22.7	9.5	8.9	0.8	8.6	14.8	2.8
Mountain	0.0493	0.0398	0.0318	0.0450	0.0387										
	(0.0169)	(0.0157)	(0.0477)	(0.0200)	(0.0235)	−33.9	−33.2	−38.8	−29.2	−21.1	34.4	39.6	150.1	44.5	60.7
Pacific	0.0679	0.0853	0.0707	0.0869	0.0575										
	(0.0176)	(0.0338)	(0.0279)	(0.0215)	(0.0278)	−8.9	43.2	36.2	36.7	17.3	25.9	39.7	39.5	24.8	48.3
AK and HI	0.0786	0.0653	0.0559	0.0261	0.0265										
	(0.1408)	(0.0840)	(0.1568)	(0.0071)	(0.0083)	5.4	9.7	7.6	−59.0	−46.0	179.2	128.5	280.6	27.4	31.3
National average	0.0745	0.0595	0.0519	0.0636	0.0490										
	(0.0309)	(0.0344)	(0.0440)	(0.0402)	(0.0329)						41.5	57.8	84.8	63.2	67.0

Table II. DuPont expansion ratio: asset turnover

Region	Average/std. dev. of ratio 1960s	1970s	1980s	1990s	2000s	Percent change from national average 1960s	1970s	1980s	1990s	2000s	Coeff. of var. for asset turnover 1960s	1970s	1980s	1990s	2000s
Northeast	0.3162	0.2462	0.2300	0.2384	0.2216										
	(0.0786)	(0.076)	(0.0623)	(0.0810)	(0.0829)	41.6	28.0	21.6	8.9	14.6	24.9	31.2	27.1	34.0	37.4
Lake States	0.2275	0.1959	0.2112	0.2358	0.1778										
	(0.0245)	(0.010)	(0.0129)	(0.0165)	(0.0173)	1.9	1.8	11.6	7.7	−8.0	10.8	5.6	6.1	7.0	9.8
Corn Belt	0.1974	0.1646	0.1673	0.1824	0.1428										
	(0.0206)	(0.015)	(0.0212)	(0.0222)	(0.0829)	−11.6	−14.5	−11.6	−16.7	−26.1	10.5	9.5	12.7	12.2	58.1
Northern Plains	0.1987	0.1895	0.2001	0.2418	0.2207										
	(0.0245)	(0.010)	(0.0129)	(0.0165)	(0.0829)	−11.0	−1.5	5.8	10.4	14.2	12.3	5.8	6.5	6.8	37.6
Appalachia	0.2015	0.1585	0.1825	0.2066	0.1850										
	(0.0367)	(0.051)	(0.0576)	(0.1044)	(0.0829)	−9.8	−17.6	−3.5	−5.6	−4.3	18.2	32.2	31.6	50.5	44.8
Southeast	0.2422	0.2116	0.2208	0.2680	0.2290										
	(0.0351)	(0.018)	(0.0259)	(0.0446)	(0.0829)	8.5	10.0	16.7	22.4	18.5	14.5	8.6	11.7	16.6	36.2
Delta States	0.2095	0.1960	0.1900	0.2918	0.2381										
	(0.0389)	(0.037)	(0.0446)	(0.0276)	(0.0829)	−6.2	1.9	0.5	33.3	23.2	18.6	18.9	23.5	9.5	34.8
Southern Plains	0.1503	0.1454	0.1411	0.1922	0.1737										
	(0.0040)	(0.001)	(0.0137)	(0.0088)	(0.0829)	−32.7	−24.4	−25.4	−12.2	−10.1	2.7	1.2	9.7	4.6	47.7
Mountain	0.1684	0.1560	0.1400	0.1641	0.1492										
	(0.0380)	(0.046)	(0.0487)	(0.0535)	(0.0829)	−24.6	−18.9	−26.0	−25.1	−22.8	22.6	29.8	34.8	32.6	55.6
Pacific	0.1997	0.2236	0.2139	0.2811	0.2636										
	(0.0234)	(0.068)	(0.0407)	(0.0520)	(0.0829)	−10.6	16.2	13.1	28.4	36.4	11.7	30.6	19.0	18.5	31.4
AK and HI	0.2313	0.1964	0.1317	0.1169	0.1172										
	(0.2041)	(0.183)	(0.1265)	(0.0619)	(0.0829)	3.6	2.1	−30.4	−46.6	−39.4	88.2	93.2	96.1	52.9	70.7
National average	0.2233	0.1924	0.1892	0.2190	0.1933										
	(0.0683)	(0.060)	(0.0657)	(0.0801)	(0.0730)						30.6	31.2	34.7	36.6	37.8

Table III.
DuPont expansion ratio: profit margin

Region	Average/std. dev. of ratio 1960s	1970s	1980s	1990s	2000s	Percent change from national average 1960s	1970s	1980s	1990s	2000s	Coeff. of var. for profit margins 1960s	1970s	1980s	1990s	2000s
Northeast	0.2338	0.1809	0.2074	0.1996	0.1505										
	(0.0223)	(0.0351)	(0.0867)	(0.0509)	(0.0623)	−16.3	−25.3	3.8	−16.1	−27.5	9.5	19.4	41.8	25.5	41.4
Lake States	0.3082	0.2778	0.1827	0.1550	0.1327										
	(0.0432)	(0.0418)	(0.0348)	(0.0414)	(0.0767)	10.4	14.7	−8.5	−34.8	−36.0	14.0	15.0	19.1	26.7	57.7
Corn Belt	0.3047	0.2768	0.1840	0.2385	0.2176										
	(0.0255)	(0.0297)	(0.0337)	(0.0559)	(0.0371)	9.1	14.3	−7.9	0.3	4.9	8.4	10.7	18.3	23.4	17.1
Northern Plains	0.3342	0.3034	0.1919	0.2852	0.2275										
	(0.0432)	(0.0418)	(0.0348)	(0.0414)	(0.0767)	19.7	25.3	−3.9	19.9	9.7	12.9	13.8	18.1	14.5	33.7
Appalachia	0.3217	0.2700	0.1972	0.2766	0.2321										
	(0.1168)	(0.3290)	(0.0941)	(0.2964)	(0.1384)	15.2	11.5	−1.3	16.3	11.9	36.3	121.8	47.7	107.2	59.6
Southeast	0.3260	0.2736	0.2262	0.3162	0.3044										
	(0.0334)	(0.0489)	(0.1005)	(0.0519)	(0.0483)	16.8	13.0	13.2	32.9	46.7	10.2	17.9	44.4	16.4	15.9
Delta States	0.3378	0.3252	0.1948	0.2659	0.2423										
	(0.0306)	(0.0291)	(0.0332)	(0.0330)	(0.0292)	21.0	34.3	−2.5	11.8	16.8	9.0	8.9	17.1	12.4	12.0
Southern Plains	0.2847	0.2180	0.1611	0.2217	0.2669										
	(0.0109)	(0.0068)	(0.0179)	(0.0542)	(0.0167)	2.0	−10.0	−19.3	−6.8	28.6	3.8	3.1	11.1	24.4	6.3
Mountain	0.2349	0.1921	0.1719	0.2350	0.2230										
	(0.0535)	(0.0445)	(0.2807)	(0.0576)	(0.0595)	−15.9	−20.7	−13.9	−1.2	7.5	22.8	23.1	163.3	24.5	26.7
Pacific	0.2785	0.2928	0.2440	0.2547	0.1704										
	(0.0450)	(0.0502)	(0.0563)	(0.0144)	(0.0321)	−0.3	20.9	22.1	7.1	−17.9	16.1	17.1	23.1	5.6	18.9
AK and HI	0.2244	0.2453	0.2210	0.2362	0.2145										
	(0.1195)	(0.0327)	(0.1931)	(0.0600)	(0.0058)	−19.6	1.3	10.7	−0.7	3.4	53.2	13.3	87.3	25.4	2.7
National average	0.2792	0.2422	0.1997	0.2378	0.2075										
	(0.0668)	(0.0981)	(0.1300)	(0.0891)	(0.0860)						23.9	40.5	65.1	37.5	41.4

Table IV. DuPont expansion ratio: asset to equity

Region	Average/std. dev. of ratio 1960s	1970s	1980s	1990s	2000s	Percent change from national average 1960s	1970s	1980s	1990s	2000s	Coeff. of var. for asset to equity 1960s	1970s	1980s	1990s	2000s
Northeast	1.1695	1.1836	1.1816	1.1482	1.1635										
	(0.0518)	(0.0567)	(0.0683)	(0.0547)	(0.0617)	−1.0	−0.7	−3.1	−1.3	0.1	4.4	4.8	5.8	4.8	5.3
Lake States	1.2144	1.2263	1.2950	1.2184	1.1876										
	(0.0265)	(0.0148)	(0.0131)	(0.0341)	(0.0468)	2.8	2.9	6.2	4.8	2.1	2.2	1.2	1.0	2.8	3.9
Corn Belt	1.1780	1.1784	1.2345	1.1690	1.1592										
	(0.0308)	(0.0296)	(0.0485)	(0.0330)	(0.0353)	−0.3	−1.2	1.2	0.5	−0.3	2.6	2.5	3.9	2.8	3.0
Northern Plains	1.1961	1.2133	1.2699	1.2264	1.2326										
	(0.0265)	(0.0148)	(0.0131)	(0.0341)	(0.0468)	1.3	1.8	4.1	5.5	6.0	2.2	1.2	1.0	2.8	3.8
Appalachia	1.1438	1.1697	1.2066	1.1392	1.1330										
	(0.0253)	(0.0411)	(0.0358)	(0.0297)	(0.0290)	−3.2	−1.9	−1.0	−2.0	−2.6	2.2	3.5	3.0	2.6	2.6
Southeast	1.1669	1.2041	1.2544	1.1593	1.1657										
	(0.0317)	(0.0326)	(0.0611)	(0.0339)	(0.0195)	−1.2	1.0	2.9	−0.3	0.2	2.7	2.7	4.9	2.9	1.7
Delta States	1.1734	1.2018	1.2786	1.2273	1.2187										
	(0.0455)	(0.0305)	(0.0480)	(0.0068)	(0.0319)	−0.6	0.8	4.9	5.5	4.8	3.9	2.5	3.8	0.6	2.6
Southern Plains	1.1695	1.1814	1.2004	1.1704	1.1650										
	(0.0196)	(0.0289)	(0.0692)	(0.0485)	(0.0391)	−1.0	−0.9	−1.6	0.6	0.2	1.7	2.4	5.8	4.1	3.4
Mountain	1.2326	1.2052	1.1967	1.1343	1.1235										
	(0.0444)	(0.0461)	(0.0585)	(0.0532)	(0.0569)	4.4	1.1	−1.9	−2.5	−3.4	3.6	3.8	4.9	4.7	5.1
Pacific	1.2049	1.2475	1.2634	1.1937	1.2064										
	(0.0131)	(0.0292)	(0.0214)	(0.0278)	(0.0523)	2.0	4.6	3.6	2.7	3.7	1.1	2.3	1.7	2.3	4.3
AK and HI	1.0768	1.0792	1.0879	1.0515	1.0549										
	(0.0274)	(0.0130)	(0.0097)	(0.0280)	(0.0219)	−8.8	−9.5	−10.8	−9.6	−9.3	2.5	1.2	0.9	2.7	2.1
National average	1.1811	1.1923	1.2194	1.1629	1.1628										
	(0.0494)	(0.0490)	(0.0677)	(0.0554)	(0.0586)						4.2	4.1	5.5	4.8	5.0

Pacific regions. This trend may reverse with higher corn prices in recent years usually attributed to the biofuels boom.

These results point to two scenarios for commercial agriculture. First, low asset turnover ratios imply that the revenues generated from commercial agriculture are insufficient to justify the observed asset base. Consequently, agriculture in such a region with low asset turnover appears overcapitalized. Perhaps this occurs because of the potential fixity of agricultural assets may limit optimal changes in asset levels. Specifically, farmland is the dominant asset on the agricultural balance sheet (Mishra *et al.*, 2004, 2008). Under typical assumptions aggregate farmland is relatively fixed. Intermediate equipment may relatively provide more flexibility.

A second possibility involves low profit margins on sales. Only the Mountain region has profit margins that are lower than the national average for all decades. The Northeast has profit margins below the national average in all years except the 1980s. Like the turnover ratio, aggregate farm level implications of the profit margin may be somewhat different. Specifically, aggregate agricultural sales are a function of the aggregate demand for food and fiber in both domestic and international markets. Therefore, unlike the individual firm that may expand sales through marketing efforts, aggregate sales for the agricultural sector is largely exogenous. Consequently, any improvement in the profit margin for the aggregate farm sector will be primarily through reduction in the cost of production. Two general factors that contribute to a reduction in the cost of production are technological innovations (i.e. biotechnology) and increased vertical integration in the sector.

Results of pooling the DuPont expansion

Given the estimated means and standard deviations of the DuPont ratios presented in Tables I-IV, the next question involves the statistical significance of the differences across regions. Table V presents the statistical significance of the differences in DuPont ratios across regions within a given time period and across time periods for a given region. The first portion of the table presents the χ^2_{18} statistics for the hypothesis that the mean and variance for each ratio is the same in each region, while the second portion of the table presents the χ^2_6 statistics for each region possessing the same DuPont ratio across time.

These results indicate that the national DuPont expansion is inconsistent with the data. However, pooling the results across years indicates some similarities in the DuPont expansion for specific regions. Since the Pacific region appears relatively similar across the years, we reject the pooling of the mean and variance only for the solvency ratio. Likewise, Alaska and Hawaii do not yield statistically significant variation across time. The consistency of the rate of return to all factors is rejected for the remaining regions. Specifically, the constancy of the rate of return to all factors is rejected at the 0.05 confidence level for the Northeast, Corn Belt, Northern Plains, Southeast, Southern Plains, and Mountain States, and at the 10 percent confidence level for the Lake and Delta Sates region. Since the rate of return to all factors is a function of the profit margin, the asset turnover ratio, and solvency (debt to asset ratio), we examine each of these components of the DuPont expansion of (*R*/*E*).

Using a likelihood ratio test our results show that we must consistently reject constancy of the profit margin across the regions (Table V, upper panel). However, we cannot reject constancy of the asset turnover or the solvency ratio across these regions over time (Table V, lower panel). For example, we fail to reject constancy in asset turnover for the Lake, Corn Belt, Southeast, Mountain, and Pacific regions

	Rate to all factors	Asset turnover	Profit margin	Asset to equity
Pooling across regions				
1960s	61.076*	77.422*	63.294*	49.535*
1970s	71.011*	66.348*	83.602*	44.410*
1980s	54.137*	55.021*	58.826*	57.966*
1990s	75.747*	62.661*	50.379*	63.722*
2000s	67.045*	57.066*	73.923*	54.692*
Pooling across time				
Northeast	13.944**	12.006***	28.155*	5.272
Lake States	11.855***	10.404	20.621*	22.261*
Corn Belt	14.785**	8.139	27.102*	12.918**
Northern Plains	15.368**	13.592**	14.228**	18.922*
Southeast	17.073*	7.817	19.690*	14.918**
Delta States	11.818***	10.797***	21.950*	21.634*
Southern Plains	34.392*	24.125*	25.789*	4.817
Mountain	26.322*	3.803	46.549*	13.815**
Pacific	3.800	6.942	7.506	17.664*
AK and HI	0.344	0.134	0.272	0.298

Notes: *Denotes statistical significance at the 0.10 confidence level; **denotes statistical significance at the 0.05 confidence level; ***denotes statistical significance at the 0.01 confidence level

Table V. Likelihood ratios for cross regional and time series pooling of mean and variances

as well as for Alaska and Hawaii. Further, the constancy of the asset turnover is rejected at the 10 percent confidence level for the Northeast and Delta States. Table V shows that that changes in the distribution of the asset turnover ratio (significant at the 5 percent or higher confidence level for the Northern Plains and Southern Plains) are not very significant over time. Results in Table V (lower panel), also show that constancy of solvency (asset to equity) cannot be rejected for all regions. These regions include Northeast and Southern Plains and Alaska and Hawaii. However, numbers presented in Tables I-IV show a lack of variation in solvency (asset to equity) across regions. Thus, changes in the distribution of the rate of returns to all factors for the regions are primarily due to changes in the distribution of the profit margins.

Implications for farmland values using the DuPont formulation

As discussed in the development of the DuPont expansion, any possible linkage between farm asset values and government payments occurs through the effect of government payments on the rate of return to assets. Melichar (1979) points out that government payments do not raise the current return but rather change the allocation of total returns between current "cash flow" and accrued capital gains. Thus, using the portion of the DuPont expansion which models the rate of return on assets, government payments could either affect returns by its impact on the profit margin or by its impact on the asset turnover ratio. To examine these two possibilities, we regress the change in logarithms of the profit margin and asset turnover ratios on the logarithmic change in government payments using a fixed effects panel formulation for state level data. The results of this analysis, presented in Table VI, indicate that the hypothesis that changes in government payments do not affect the profit margin can be rejected at the 0.05 level of confidence, but the hypothesis that government payments affects the asset turnover ratio can be rejected at any conventional confidence level. Thus, our results suggest that government payments affect farm asset values (*vis-à-vis* farmland values) through changes in the profit margin, but not through changes in the asset turnover ratio. This is consistent with the Ricardian notion that government payments will be capitalized into the values of fixed and quasi-fixed factors, such as farmland (Mishra *et al.*, 2004). This is clearly seen in today's farmland markets as farm asset values reflect expectations regarding income growth, including government payments (Leopold Center for Sustainable Agriculture, 2004). However, given asset fixity, government payments generally do not affect farm asset values through the asset turnover ratio because farm operators face adjustment costs in changing their capital structures. This is also consistent with Melichar's (1979) argument that income support programs do not affect long-run total returns but rather their composition between "cash flow" returns and accrued capital gains. This conclusion contradicts the findings of Hopkins and Morehart (2002) who conclude changes in government payments affect farmland values by affecting the asset turnover ratio. Further, anecdotal evidence suggests that once a farmer buys farmland it is very unlikely that they will sell it in the very near future. Empirically, the results suggest that a one percent increase in government payments increases the profit margin by 0.05 percent.

Table VII presents the computed effect of government payments on farmland values through a change in profit margins. Following the logic of the derivation from Equation (16), a one percent increase in government payments may have a negative impact on land values, if the state currently receives large transfers. Intuitively, if government payments already represent more than 5 percent of the gross margins, expanding profit margins through a one percent increase in government payments provides a lower return than the profit margin (or more specifically, the new rate of government payments is lower than the existing rate of government payments). For example, direct government payments accounted for 7.8 percent of average revenues in Louisiana between 1949 and 2006. Following the implications in Table VI, a one percent increase in government revenues would represent a 0.05 percent increase in profit margins. In this case, the marginal rate of increase from the last dollar of direct government payments is less than the average rate of increase. On the other side, California government payments represented 1.4 percent of total revenues over the 1949 through 2006 time period. By applying the pooled result, a one percent increase in government payments would increase the profit margin by 5.0 percent implying an increase in farmland prices of 3.4 percent. Following Equation 16 the insight is that a significant expectation of government payments is already priced into farmland values at the state level. Thus, for those states that have received relatively large subsidies over time, an across-the-board increase in government payments would actually represent a relative reduction in government payments at the margin. The result may also suggest re-estimating the results in Table VI at a more disaggregate level.

Table VI.
Effect of government payments on farmland values through DuPont expansion

	Constant	Change in government payments
Change in profit margin	−0.0205*** (0.0110)[a]	0.0481** (0.0206)
Change in asset turnover	−0.0060* (0.0023)	0.0054 (0.0043)

Notes: [a]Numbers in parenthesis denote standard errors; *denotes statistical significance at the 0.10 confidence level; **denotes statistical significance at the 0.05 confidence level; ***denotes statistical significance at the 0.01 confidence level

State	Share of direct government payments	Percentage change in farmland price	State	Share of direct government payments	Percentage change in farmland price
Alabama	0.0390	0.0091	Nebraska	0.0621	−0.0140
Arizona	0.0293	0.0188	Nevada	0.0166	0.0315***
Arkansas	0.0586	−0.0105	New Hampshire	0.0126	0.0355**
California	0.0142	0.0339**	New Jersey	0.0103	0.0378**
Colorado	0.1583	−0.1102*	New Mexico	0.0438	0.0043
Connecticut	0.0063	0.0418**	New York	0.0178	0.0303***
Delaware	0.0105	0.0376**	North Carolina	0.0229	0.0252
Florida	0.0098	0.0383**	North Dakota	0.1298	−0.0817*
Georgia	0.0381	0.0100	Ohio	0.0443	0.0038
Idaho	0.0404	0.0077	Oklahoma	0.0628	−0.0147
Illinois	0.0645	−0.0164	Oregon	0.0255	0.0226
Indiana	0.0552	−0.0071	Pennsylvania	0.0146	0.0335***
Iowa	0.0607	−0.0126	Rhode Island	0.0062	0.0419**
Kansas	0.0733	−0.0252	South Carolina	0.0505	−0.0024
Kentucky	0.0333	0.0148	South Dakota	0.0756	−0.0275***
Louisiana	0.0781	−0.0300***	Tennessee	0.0493	−0.0012
Maine	0.0120	0.0361**	Texas	0.0720	−0.0239
Maryland	0.0171	0.0310***	Utah	0.0355	0.0126
Massachusetts	0.0075	0.0406**	Vermont	0.0140	0.0341**
Michigan	0.0444	0.0037	Virginia	0.0231	0.0250
Minnesota	0.0612	−0.0131	Washington	0.0344	0.0137
Mississippi	0.0749	−0.0268***	West Virginia	0.0211	0.0270***
Missouri	0.0617	−0.0136	Wisconsin	0.0321	0.0160
Montana	0.1085	−0.0604*	Wyoming	0.0410	0.0071

Notes: *Denotes statistical significance at the 0.10 confidence level; **denotes statistical significance at the 0.05 confidence level; ***denotes statistical significance at the 0.01 confidence level

Table VII. Estimated effect of government payments on farmland values from the DuPont expansion

In the current study, a one percent increase in government payments is associated with an increase in farmland values through the DuPont expansion for 30 out of the 48 contiguous states (or roughly 63 percent) (Table VII). For ten of those states, this positive effect is statistically significant at least the 0.05 level of confidence for ten of the contiguous states (or roughly 20 percent). On the negative side, the expected effect of increased government payments on farmland values through the DuPont expansion is only statistically significant at the 0.05 level of confidence for three of the contiguous states (or roughly 6 percent). Thus, taken as a whole, the data support the contention that increases in government payments lead to increased profit margins which increase the price of farmland. However, this conclusion must be tempered with the recognition that some states already receive a large share of the gross margin from government payments.

Conclusions

This study examines factors affecting agricultural profitability using the DuPont expansion. The secondary objective of this paper is to examine the effect of government payments on farm assets and, in particular, farmland values through the DuPont expansion. The results indicate that higher than average factor returns in the Southeast can be attributed both to higher than average asset efficiency measured by the asset turnover ratio and to a higher than average gross margin. The increased rate of return to factors in the Northern Plains is similarly explained by relatively high gross margins. These results can be contrasted with the results for Corn Belt and Appalachia that have relatively high gross margins but a lower asset turnover ratio. The importance of the asset turnover ratio in determining the profitability of agriculture is somewhat troubling due to the inability of the sector to influence total sales and the potential endogenous nature of farmland values.

Statistical examination of the DuPont expansion indicates that the differences in the distributions for each ratio in a given time period and region are statistically significant. Further, differences in the distribution of the rate of return on all factors across time are significant and primarily attributable to differences in the profit margin. Specifically, statistical differences in the profit margins are observed in seven of the ten ERS resource regions. Similar differences are observed for the asset-to-equity ratio.

The results of this study suggest that cross sectional variation in the rate of return to assets is primarily determined by the gross margin. The Northeast and Southeast regions can be characterized by high asset turnover ratios compared to the national average while the Mountain and Southern Plains exhibit lower than average asset turnover ratios. These differences suggest that research programs should focus on the differences in asset usage among regions. Specifically, agriculture in the Mountain and Southern Plains may be dominated by a mono-cultural agriculture with farmers producing a single crop per year. In contrast, agriculture in the Southeast may be characterized by double cropping and diversified agriculture in the Northeast. These differences would tend to increase the relative investment in farmland relative to production in the Mountain and Southern Plains. Therefore, adjustments in the asset turnover ratio may be difficult to achieve. Similarly, adjustments in the asset turnover ratio that seek to improve profitability may be difficult to achieve in the Corn Belt and Southern Plains, but for somewhat different reasons. Specifically, indivisibilities and a limited number of planting days for corn in the Corn Belt and cotton in the Southern Plains may lead to increased investment in equipment in order to manage risk.

Our results indicate that the profitability of agriculture is largely determined by the asset-turnover ratio (sales divided by farm assets). While this result is not inconsistent with the new agricultural policy paradigm, the results support the asset fixity hypothesis which has been used in the past to justify farm programs. Boom/bust cycles described by Schmitz (1995) could result from imperfections in the agricultural capital market which limit the ability to adjust total assets in the short-run. This lack of adjustment can be traced to the sector's dominant asset – farmland. In addition, our results indicate that government payments will affect farmland values primarily through their impact on gross margins. In contrast to previous studies we find no evidence that government payments affect the asset turnover ratio. One suggestion for future study is for a more complete estimation of the profit margin. Does the state's portfolio matter (i.e. the ratio of crops to livestock)? This may be an important factor in refining our estimates of the effect of government payments on farmland values.

Notes

1. However, more recently Hopkins and Morehart (2002) refuted low returns hypothesis and suggest that farmland may be responsible for inefficiency through the capitalization of government payments.
2. In this paper we refer DuPont model as DuPont expansion.

3. Net profit margin × asset turnover ratio = rate of return on assets (ROA). ROA × financial leverage (assets to equity) = rate of return on equity, Shapiro and Balbirer (2000).
4. The DuPont Corporation in the 1920s, first introduced this method of measuring financial performance and has been used by them ever since. With this method, assets are measured at their gross book value rather than at net book value in order to produce a higher return on investment (ROI). The DuPont model of financial analysis was made by F. Donald Brown, an electrical engineer in 1914. Brown used this analysis to clean out General Motors Corporation's tangled finances. Applications to agricultural finance have been through Collins (1985).
5. Melichar notes that in long-run market equilibrium, farm assets will be priced so that the total return "cash flow" current income plus (accrued) capital gains equals the market interest rate. Capital gains preceding the 1981-1986 "farm financial crisis" were followed by capital losses on farm sector assets, leading to wide swings in total returns to farm assets, and to a loss of over $248 billion in farm business wealth.
6. Mishra *et al.* (2004, 2008) note that farmland in the US accounted for more that 75 percent of the agricultural assets. However, the ratio may be even higher for Midwest region.

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